(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 602 911 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
27.05.1998 Bulletin 1998/22

(51) Int Cl.[6]: **F25B 6/02**, F25B 40/02, F25B 7/00, F25D 16/00

(21) Application number: **93309973.1**

(22) Date of filing: **10.12.1993**

(54) **Cooling system**

Kühlanlage

Système de refroidissement

(84) Designated Contracting States:
BE CH DE ES FR IT LI NL

(30) Priority: **10.12.1992 US 988656**

(43) Date of publication of application:
22.06.1994 Bulletin 1994/25

(73) Proprietor: **BALTIMORE AIRCOIL COMPANY, INC.**
Jessup, Maryland 21227 (US)

(72) Inventors:
- **McCloskey, William D.**
  Baltimore Maryland (US)
- **Brady, Thomas W.**
  Westchester DuPage Illinois (US)

(74) Representative: **Davies, Christopher Robert**
Frank B. Dehn & Co.,
European Patent Attorneys,
179 Queen Victoria Street
London EC4V 4EL (GB)

(56) References cited:

EP-A- 0 348 504	EP-A- 0 348 771
WO-A-90/14566	DE-A- 3 111 469
US-A- 4 000 626	US-A- 4 423 602
US-A- 4 567 733	US-A- 4 964 279

Description

The present invention relates to a cooling system. More specifically, the cooling system provides apparatus for coupling an ice-storage system to existing cooling and refrigeration devices to enhance their performance, efficiency and reduce the overall power consumption, or the cost to achieve the same operating result by reducing the power demand at peak operating periods.

An illustration and explanation of the need for expansion of the range of existing cooling devices, reduction of the operating expense or both conditions is provided in a brochure from the Electric Power Research Institute, "Supermarket Air Conditioning and Dehumidification". Although the modern convenience of the grocery store or supermarket with its air conditioned aisles, glassed or open-front freezers and display cases, and its cold-storage lockers is accepted by consumers, the costs to install, run or maintain these large cooling apparatus are not considered. Several alternative systems for supermarket cooling requirements are illustrated and discussed in the noted brochure, which includes notations on the capital and operating costs as well as a discussion of the relative advantages and disadvantages of the several systems. In this brochure, which appears to have been published in 1990, the utilization of an ice-storage or cool storage system is briefly discussed, however, there is no illustration or detailed description of an operating system and only a recognition of the potential benefits that would accrue from such a system.

Conventional cooling apparatus generally consist of stand alone devices, such as air-conditioners and individual refrigeration assemblies, each having its own ductwork for air transfer, cooling circuit and power connections. The coupling of an ice-storage apparatus to an existing cooling unit can reduce its period of operation to attain the same cooling capacity, thus reducing its energy consumption during a peak electrical cost period; or alternatively, it can be viewed that the operating range of the unit is expanded, which results in a "larger cooling capacity" unit without replacement. Further, multiple cooling devices can be connected to this ice-storage system for simultaneous operation. Illustrative of a facility with multiple cooling devices is the grocery store or supermarket, which commercial facility will frequently have an air-conditioning apparatus, a freezer or cooler with a door for goods such as ice-cream, an open cooler for dairy products and frozen juices, and a sub-zero cooler for storage of other foodstuffs. In a new installation, the size and configuration of some or all of the ancillary devices coupled to the ice-storage system can be reduced in size or rated capacity to deliver the same cooling capacity, which can result in an initial capital cost reduction.

Further benefits result in the ability to expand the usage of the ice-storage system to other parasitic apparatus; production of ice in the off-peak periods of electric usage, generally nighttime, reduces the cost of power to produce the requisite cooling; and, only nominal capital cost is incurred with this known basic technology.

EP-0348504 discloses an air-conditioner with a regenerating cycle and a refrigerating cycle which are formed independently of each other.

US-4423602 discloses an energy saving method that subcools previously condensed refrigerant causing an increase in the net refrigeration effect.

EP-0348771 discloses a system supplying cooling to a consumer unit, this being derived from an ice tank and a liquid cooler and delivered via a cold-water circuit. A water cooler is used as the liquid cooler, its refrigerator supplying only the ice tank when the consumer unit is not in use overnight. It supplies the unit by direct heat-exchange in the daytime.

According to the present invention there is provided a cooling system comprising at least one primary refrigeration cooled assembly and a supplemental cooling system connected thereto for reducing the temperature of refrigerant in the primary refrigeration cooled assembly upstream of a refrigerant cooled apparatus, wherein the primary refrigeration cooled assembly comprises a refrigerant circuit with a refrigerant and wherein the supplemental cooling system comprises:

refrigerant means for providing a second refrigerant;

thermal storage means having a housing with a phase change material in said housing;

freezing means for freezing at least a portion of the phase change material in the housing and for cooling a remaining portion of fluid phase change material to approximately the temperature of frozen phase change material, the freezing means being positioned in the housing and connected to the refrigerant means and wherein the freezing means is operable independently of the primary refrigeration cooled assembly;

coupling means coupled to the primary assembly refrigerant circuit for exchanging heat between refrigerant in the primary assembly refrigerant circuit and fluid phase change material in the supplemental cooling system, the coupling means having a first fluid path coupled to the primary assembly refrigerant circuit wherein in use refrigerant from the primary assembly refrigerant circuit flows through the first fluid path before returning to the primary assembly refrigerant circuit, and a second fluid path coupled to the thermal storage means wherein in use fluid phase change material from the thermal storage means flows through the second fluid path before returning to the thermal storage means; and

pumping means for pumping the fluid phase change material from the thermal storage means to the second fluid path and for returning the fluid phase change material to the thermal storage means;

wherein the fluid phase change material is at a cooler temperature in the second fluid path than the re-

frigerant in the first fluid path;

characterised in that said primary refrigeration cooled assembly further comprises:

compressing means for compressing a refrigerant vapor from a first and low pressure to a second and higher pressure;
condensing means separate from the coupling means and coupled to the compressing means for condensing at least a portion of the refrigerant vapor at the second pressure to a liquid; and
a refrigerant cooled apparatus coupled downstream from the condensing means, wherein refrigerant after passing through the refrigerant cooled apparatus is recycled to the compressing means.

A system to incorporate an ice-storage system with existing cooling and refrigeration devices without elaborate use of control valves, sensors and other control components may be provided by embodiments of the invention for usage with any air-conditioning, refrigeration or humidification/dehumidification devices. In one embodiment of the invention the ice-storage apparatus incorporates a compressor; an air-cooled, water-cooled or evaporative condenser; an ice-storage tank with a cooling coil therein; and, a fluid circulating circuit with a circulating pump, as well as conduit and expansion valves commonly associated with an ice-storage system. The compressor or compressors are operable to receive cool low-pressure refrigerant gas and compress it to a hot high-pressure gas for communication to a condenser to condense the vapor to a liquid and to dissipate the heat to the atmosphere. The high-pressure liquid is communicated to the ice-storage tank, which is filled with a fluid for freezing such as water or a water-glycol mixture. The spent refrigerant is returned to the compressors for recirculation through the circuit. During operation of the compressor(s) and condenser, ice is formed in the ice-storage tank, however, not all of the fluid may be frozen, and the compressor-freezing cycle is not continuous but is run only until the ice is formed. A parasitic or coupled cooling device may be connected to the fluid in the storage tank, which fluid is utilized to reduce the coupled-device refrigerant temperature and to enhance the operating efficiency of such coupled device, especially during peak periods of cooling demand, such as the middle of the day in hot, humid weather. The circulating pump circulates fluid from the ice-storage tank, which is approximately at the freezing temperature of the water or coolant mixture, to the coupling component of the parasitic cooling device, which component provides heat transfer to the refrigerant of the coupled device.

In an application described by way of example, where the coupled device is a low-temperature condensing application having an independent refrigerant circuit similar to the ice-storage refrigeration circuit, an auxiliary condenser can be provided for coupling to both the compressor discharge conduit and the ice-storage fluid circuit. Heat transfer between the coupled-device refrigerant and the low-temperature coolant fluid is provided in the auxiliary condenser, which provides liquid refrigerant at a temperature very much below the temperature of the liquid refrigerant from the air-cooled or evaporative condenser for transfer of a colder refrigerant liquid with little or no added power input or work from the compressor-condenser circuit of the coupled device. The cooler liquid refrigerant entering the evaporator requires less work from a compressor, the same or less work as an air cooled condenser, reduces the application device operating pressure and power consumption from the compressor, or requires less device operating time. The ice-storage fluid is returned to the ice-storage tank from the condenser. However, the low-temperature refrigerant is operable to provide the necessary temperature drop in the application, and in a supermarket this may be a refrigerated display case or low-temperature (e.g., -10 F. to -40 F. (-23 to - 40°C)) storage freezer.

Alternatively, the fluid circuit may also be connected to a coupling device for a sub-cooling application where fluid from the air-cooled or evaporative condenser is communicated to a liquid refrigerant sub-cooler for transfer to a subcooling application. The evaporating temperature of a sub-cooling application may, for example but not as a limitation, be about in the range of 0 F. to about 25 F. (-18 to - 4°C), and the required amount of fluid from the ice-storage fluid circuit may not be as great as in the above-noted low-temperature condensing application. However, one advantage may be the utilization of low-temperature fluid produced at the off-peak power cost period, to reduce demands on the refrigerant circuit of the coupled device by use of the low-temperature fluid, thereby providing operating efficiencies not otherwise available. Either of these first two applications may be used in existing supermarkets to offset the capacity loss of the compressors when a chloro fluoro carbon (CFC) refrigerant is replaced by a non-CFC refrigerant.

In another embodiment, the coolant fluid from the ice-storage fluid circuit may be diverted to an air-cooling application to provide a measure of direct heat transfer and minimize the demands on the existing equipment, such as the display area air handling unit, which may have to accommodate a dehumidification condition. Dehumidification may be accommodated by low-temperature air conditioning devices, however, this often results in the icing of the cooling coils and reduction of efficiency of the cooling apparatus. Therefore, air cooling without icing of the compressor-coupled coils would maintain their rated operating efficiency and thereby increase the overall operating efficiency of the unit without excess added cost. This is especially true in units where the air-cooling application is an added cooling device and not the primary device utilizing the ice-storage tank fluid. In the above-noted supermarket illustration, the in-store

relative humidity is more easily maintained by achieving better control of the cooling coil temperature.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:-

Fig. 1 is a diagrammatic view of the preferred embodiment of the invention with a single coolant apparatus coupled to the ice-storage fluid circuit; and,
Fig. 2 is a diagrammatic view of an exemplary view of an embodiment for a supermarket application.

The present invention provides reduced-temperature cooling to a primary cooling apparatus and is adaptable to connect multiple parasitic units for reduction of their refrigerant coolant temperatures to improve their operating efficiency, expand the operating range and/or reduce their operating cost.

Cooling system 10 in Figure 1 provides a supplemental cooling circuit 12, which is independently operable from a primary cooling or refrigeration apparatus or circuit 14, but operably coupled to the circuit through a coupling apparatus, shown as an auxiliary condenser 16. In this embodiment, refrigeration apparatus 14 is a low-temperature evaporating application such as a display or storage cooler in a supermarket. This form of an application is considered a low-temperature application, as it is operable in a temperature range of about -10 to -40 degrees F (-23 to -40°C). In the same vein, a moderate temperature application will be about in the 0 - 25 degree F (-18 to -4°C), range, and a high-temperature application will be above about 32 degrees F.(0°C). There are some obvious gaps in the temperature ranges, but the ranges are merely illustrations, not limitations.

Refrigeration apparatus 14 has at least one compressor 18 and, as shown in Figure 1, may have a plurality of compressors 18 arranged in parallel to provide compression of a low-pressure gas. The low-pressure refrigerant vapor is transferred by conduit 20 to input ports 22 of each of compressors 18 for compression to a warm high-pressure vapor. The terms high and low-pressure refer to the difference in the pressures across the operating devices, such as the compressors, not to the absolute pressures of the fluids and vapors. The warm, high-pressure refrigerant vapor is communicated to entry passage 24 of air-cooled or evaporative condenser 26 through conduit 28 from discharge ports 30 of compressors 18. The warm refrigerant vapor is cooled and condensed in condenser 26 to provide a refrigerant liquid at output passage 32, which fluid is communicated to display or storage area 34 through conduit 36, to cool area 34 to a desired temperature. Condenser 26 is operable in a standard manner to condense the vapor to a fluid and discharge the evolved heat to the atmosphere. Refrigeration apparatus 14 is thus seen to be a conventional installation of a cooling device or cooling circuit for a specific application.

Supplemental cooling circuit 12 in Figure 1 is an ice-storage assembly. More specifically, circuit 12 has ice-storage equipment 38, such as taught and illustrated in U.S. Patent No. 4,964,279 to Osborne, which utilizes a compressor, condenser and an ice-storage facility with a cooling coil to freeze a cooling fluid in the tank. The frozen mass, which may include both solid and liquid, provides reduced temperature material for coupling to an ancillary cooling circuit to assist in the cooling function.

Circuit 12 in Figure 1 has coolant pump 40 coupled between ice-storage equipment 38 and condenser 16 to pump reduced temperature fluid, such as ice-water, to condenser 16 from equipment 38. Condenser 16 is an example of coupling apparatus between refrigeration device 14 and cooling circuit 12. Fluid return conduit 42 between condenser 16 and equipment 38 communicates spent cooling fluid from condenser 16 to equipment 38 for recycling therein.

In Figure 1, auxiliary condenser 16, which may be a counterflow tube heat exchange device or other known apparatus, is coupled at its input port 44 by connecting line 46 to conduit 28 for transfer of high-pressure vapor to condenser 16. A temperature drop from ambient temperature in condenser 16, which is induced by coolant fluid from ice-storage equipment 38 being pumped by pump 40 to condenser 16 in response to an external signal from a sensing and signal device 48. This sensing and signal device 48 is coupled to pump 40 by line 50 and may be any one of known sensing and signal device, for example, a humidstat, a thermostat or a timer, to activate pump 40 for transfer of the reduced-temperature fluid from equipment 38 to condenser 16. Discharge port 52 of condenser 16 is coupled to liquid refrigerant line 36 by line 54 to communicate refrigerant fluid from auxiliary condenser 16 to line 36, which refrigerant from auxiliary condenser 16 is chilled by ice-storage fluid to a temperature less than liquid refrigerant from primary condenser 26. This increased temperature drop in the refrigerant of apparatus 34 expands the operating range of an existing cooling circuit 14. The decreased refrigerant temperature will induce an increased temperature drop in apparatus 34 without adding either increased compressor loading or added capacity to condenser 26 to achieve a required temperature drop at apparatus 34. Further, the coupling network associated with auxiliary condenser 16, the coupling device, does not require a plurality of control valves and sensors, as the fluid flow through lines 46 and 54 is actuated by the differential temperature of fluid flow from pump 40. The drop-leg arrangement is known in the art and is utilized in system 10 to obviate the usage of unnecessary control valves. Condenser 26 does not have to be deactuated when condenser 16 is activated as operation of condenser 16 and the "drop-leg" effect effectively stops the flow of refrigerant to condenser 26. However, the fans usually associated with condensers should be turned off to conserve energy.

In the above-noted supermarket application, the expanded operating-temperature range provides added cooling capacity and reduces operating power consumption to the primary cooling circuit 14 without increasing the capacity or number of compressors 18. This latter advantage provides the required operating capacity for the circuit 14 under extreme temperature and humidity conditions, such as hot, humid summer conditions in sunbelt environments. In Figure 1, supplemental cooling circuit 12 is coupled to a single cooling circuit, but it is couplable to a plurality of ancillary cooling circuits to simultaneously provide increased cooling capacity to these several alternative units.

In an illustrative and detailed embodiment of the present invention shown in Figure 2, supplemental cooling circuit 12 has a compressor rack or assembly 70, which has a plurality of compressors, such as compressors 18, arranged in a parallel alignment and operable to receive a refrigerant vapor at a relatively low pressure for compression to a higher presssure and discharge through a discharge port 30 at the second and higher pressure to a conduit 72. Conduit 72 is coupled between discharge port or ports 30 and inlet passage 74 of condenser 76, which is operable to condense the high-pressure vapor to a liquid for transfer through output passage 78 and coil 80 in ice-storage tank 82. Coil 80 is coupled to compressor rack 70 by conduit 84 to return the spent coolant fluid as warm, low-pressure vapor to the input ports 86 of the compressors 18 of rack 70. Chamber 88 of tank 82 has a fluid, such as water or a water/glycol mixture, which may be frozen on coils 80, either completely or partially. Generally the partially frozen fluid in tank 82 is approximately at its freezing temperature, but still a liquid for pumping, that is at least some of the liquid has not experienced a change of state and may be pumped as a liquid. In this figure, circulating pump 40 is coupled to an outlet opening 90 of tank 82 and has a downstream conduit 92 for transfer of the cold liquid from chamber 88. Return conduit 94 extends from return-fluid opening 96 and is coupled in a closed loop arrangement for return of all spent or warmed liquid to tank chamber 88.

The low-temperature evaporating application described for circuit 14, and more specifically auxiliary condenser 16, is coupled to downstream conduit 92 by conduit 98 for communication of the cooled liquid from chamber 88 at activation of pump 40 by signal device 48. In addition, fluid circuit 14 has a liquid receiver 100 in parallel with liquid refrigerant conduit 102, which is connected to both conduits 54 and 36 to communicate liquid refrigerant to evaporator apparatus 34. Liquid receiver 100 is only provided as a reservoir apparatus for liquid refrigerant. As noted in this figure, discharge conduit is connected to return conduit 94 for recycling of spent cooling fluid from condenser 16.

Alternative cooling apparatus 120, such as a subcooling application for an intermediate or moderate temperature cooling application in the above-noted supermarket environment, again utilizes a compressor rack or assembly 122, which may have a plurality of compressors 18, an air-cooled or evaporative condenser 124, compressed vapor line 126, condensed liquid line 128, liquid receiver 130 in parallel with line 128, and application device or apparatus 132, which may be an evaporator or multiple evaporators. Refrigerant return line 134 from apparatus 132 is coupled to compressor rack 122 for recycling of the warm, low-pressure refrigeration vapor from apparatus 132. A liquid sub-cooler 136 is the coupling apparatus in fluid circuit 120 and is coupled in line 128 between apparatus 132 and condenser 124 for communication of the liquid refrigerant therethrough. Sub-cooler 136 is also coupled to downstream conduit 92 in parallel with apparatus circuit 14 to receive low-temperature fluid from chamber 88 to cool refrigerant below the exiting-liquid temperature from condenser 124. Conduit 140 connects downstream conduit 92 with sub-cooler inlet port 142 and, sub-cooler outlet port 144 is connected to return conduit 94 by line 146, which in the figure is joined with discharge line 42 at junction 149 to form conduit 151. Sub-cooler 136 may operate similarly to auxiliary condenser 16 to reduce the temperature of refrigerant passing through sub-cooler 136 to apparatus 132. The coolant fluid from tank chamber 88 may only be communicated to sub-cooler 136 at actuation of pump 40, however, the rate of fluid flow through sub-cooler 136 may be a function of the size of conduit 140, an orifice valve or other control parameter, if required by the specific application.

Air-cooling application or apparatus 160, such as an air handling unit for a display area, is illustrated as coupled to downstream conduit 92 to provide communication of coolant fluid from tank chamber 88 to apparatus 160. Control valve 162 is coupled between downstream conduit 92 at first port 164, and to return conduit 94 at second port 166. In a reference operating mode, fluid from conduit 92 passes through valve 162 for communication to return conduit 94. Circulating pump 170 is coupled between conduit 92 at its input passage 172 upstream of first port 164, and at its output passage 178 by conduit 176 to entry 173 of heat exchange device 174 in apparatus 160. Conduit 180 couples exit 175 with third port 168 of valve 162. Signal and/or sensing device 182 is coupled to pump 170 by line 184, and is operable to actuate fluid pump 170 to initiate flow to apparatus 160. In operation, coolant fluid flowing through conduit 92 and valve 162 to conduit 94 during actuation of first pump 40 may be electably communicated to apparatus 160 by actuation of circulating pump 170. Coolant fluid is diverted to apparatus 160 through heat exchanger 174 and third port 168 for transfer to return conduit 94. In this alternative mode, first port 164 is closed to divert fluid flow through pump 170 and valve 162 is controllable to maintain a desired temperature and relative humidity in an operating area.

The utilization of system 12 and the advantages associated therewith are exemplified by the illustration of

Figure 2. The potential advantages of coupling an ice-storage system with conventional air-cooling and refrigeration apparatus were noted in the above-cited EPRI brochure, however, the specific structure and arrangement of the components, as well as the coupling apparatus and their interactions have not previously been disclosed without multiple control valves, which control-valve circuit is disclosed and illustrated in U.S. Patent No. 4,637,219 to Grose. Further, the coupling of multiple cooling and refrigeration apparatus to a single ice-storage assembly to draw on its cooling mass with a relatively simple piping network has not been previously disclosed or known generally and especially for a supermarket application. In operation, the system of Figure 2 displays an outward appearance of a complex network, however, it is to be noted that low-temperature condensing application 14, liquid sub-cooling application 120 and air-cooling application 160 along with their associated components are extant structures in the supermarket environment, which structures are available on twenty-four hour duty in many facilities. Coupling of the ice-storage apparatus and the associated coupling devices require only nominal space, minimal capital outlay and a major potential reduction of power costs, as evidenced by the reallocation of available resources to lower cost operations. Further reductions in operating costs are available by adaptating ice-storage system 12 to existing cooling systems, which expands their operating range by retrofit rather than replacement with larger, more-expensive-to-operate structures to produce the same cooling or refrigeration capacity.

In operation, the illustrative system noted in Figure 2 couples an ice-storage assembly 12 to coupling or control devices 16, 136to provide on-demand cooling capacity beyond rated equipment capacities at "design" conditions or to reduce power demands during peak-cost periods for power. Assembly 12 is operable to provide a mass of frozen fluid, such as water or a water/glycol mixture, in storage tank 88. In the illustrated assembly 12, compressors 18 of rack 70 compress a low-pressure vapor refrigerant from conduit 84 to a high-pressure vapor refrigerant discharged to conduit 72 and condenser 76, which condenses the high-pressure vapor to a fluid for transfer to cooling coils 80 in tank chamber 88. This cooling circuit may incorporate thermal expansion valves or other standard equipment not specifically illustrated but known in the art. The refrigerant fluid in coils 88 cools and can freeze at least some of the coolant fluid to provide a liquid-solid fluid mass in tank 82, preferably at periods when the power costs are at a minimum, which in the hot, humid summer months, is usually the night time hours. This utilization of the off-peak power demand reduces operating costs as the frozen fluid is retained in an insulated tank 82 for later use. After the fluid is frozen, or after a period of operation, or other operational criteria, the compressors of rack 70 are deactivated and the system is on a standby mode. At peak coolant demand periods, such as the middle of a hot, humid summer day, electric power costs may be at a maximum for kilowatt-hour rates and existing equipment may be unable to provide adequate cooling to meet the application demands, or the existing equipment may be required to operate at its rated or peak capacity, which places undue demands on the equipment and may increase the associated maintenance costs. The use of coolant fluid from tank 82 in the sub-cooling operation reduces the load on compressors 18, which would allow at least some of the compressors to be cycled to an inoperative mode and to allow the remaining compressors to operate at lower discharge pressures.

In Figure 2, the chilled fluid in ice-storage tank 82 can be circulated to coupling devices 16 and 136 of applications 34 and 132, respectively, for interaction with the application refrigerants to reduce their operating temperatures below the temperature available with the standard operating modes. More specifically, pump 40 is activated to circulate coolant fluid from tank 82, which is at or about the freezing temperature of the frozen material therein, to coupling devices 16, 136. Simultaneously the refrigerants of the coupled applications flow through the coupling devices and their temperatures are significantly reduced to provide a much lower fluid temperature to the apparatus or area being cooled. In the noted application circuits, there are no added control valves, rather the ice-storage fluid is continuously circulated to the coupling devices 16 and 136. In the case of the low-temperature condensing application 34, coolant fluid communicated to condenser 16 causes the refrigerant gas to condense to a liquid in condenser 16, which liquid fills conduit 54. The static height of liquid in conduit 54 creates sufficient pressure to effectively stop refrigerant flow through conduit 36 from condenser 26, which induces reduced temperature refrigerant to be communicated from condenser 16 to conduit 102 and apparatus 34. The lower temperature refrigerant expands the temperature range of this low-temperature condensing application and can maintain the desired operating temperature on unseasonably warm days or conditions without causing excessive demands on the compressor-condenser refrigerant circuit, which reduces the power consumption of the circuit. Refrigerant flow through auxiliary condenser 16 may be ceased by discontinuing coolant fluid flow from tank 82. In circuit 14, coolant fluid is circulated through auxiliary condenser 16 and transferred to return conduits 42, 151 and 94. The rate of fluid flow, refrigerant flow, temperature drop and other operating parameters are dependent upon the dimensions of the several components and their operating capacities, as well as environmental conditions. Pump 40, which is coupled between tank 82 and the coolant fluid flow circuit is actuable by signal/sensing device 48 to initiate coolant flow to the several cooling application devices in response to an external parameter, such as time, temperature, humidity or other operating condition. This actuation signal may be manual initiation of

pump 40, the specific actuation means is not a limitation to the invention.

In the liquid sub-cooling application with apparatus 132, coolant fluid is continuously provided to subcooler 136 during operation of pump 40. The coolant flow rate may be controlled through the use of an orifice valve, sized piping or other control devices, if desired. However, refrigerant flow from air-cooled or evaporative condenser 124 of the refrigerant circuit is continuously transferred through sub-cooler 136 under all operating conditions in this exemplary cooling-application structure. The degree of sub-cooling of the refrigerant may be controlled or be responsive to the flow rates of the refrigerant and coolant fluid, the ambient temperature, the relative temperatures of the two fluids or other operating and environmental parameters. The precise drop in refrigerant temperature may be controlled by existing control devices on the extant cooling circuit for apparatus 132. Spent coolant fluid is communicated from sub-cooler 136 to return conduits 146, 149, 151 and 94 for recycling in tank 82. This process effectively increases the operating capacity of the existing compressors 18 without added capital investment in more or larger compressors.

Coolant flow to air-cooling apparatus 160 is electable by actuation of circulating pump 170 to divert coolant fluid from conduit 92 ahead of control valve 162. In this application, coolant fluid is directed through apparatus 160 to reduce the temperature of the heat-transfer component. In the reference mode with pump 170 deactivated, the coolant fluid is directly routed from line 92 through valve 162 for return to conduit 94 and tank 82. Circulating pump 170 is actuable by signal/sensing means 182 to open fluid flow to apparatus 160 ahead of valve 162, and in this sense pump 172 is operable as a valve or control device to limit fluid flow to apparatus 160.

In an alternative embodiment in Figure 2, dashed line 123 extends between conduit 126 of sub-cooling application 120 and conduit 72 connected to condenser 76 of ice-storage system 12. In this embodiment, it is contemplated that compressor rack 122 may be operable in a dual-mode operation, that is it may operate in its convential mode during normal operating periods with sub-cooling circuit 120 and in off-peak periods or during normally low-usage periods, such as night time, this compressor rack 122 could be utilized in conjunction with ice-storage circuit 12 to freeze the coolant fluid in tank 82. If a modulated or controlled degree of subcooling is desired a two-way control valve may be provided in conduit 146 and modulated generally toward a closed position as less subcooling is desired.

In the Figure, return line 125 provides recycling of refrigerant to compressor rack 122. Control assembly 127, which is shown in line 125 but may be positioned in line 123, is operable to divert refrigerant flow to ice-storage assembly 12. This dual mode application would provide further capital cost savings, minimize the space requirements and maximize equipment utilization. The variations of this alternate use are many and include the use of the compressors 18 from low-temperature condensing application 14 in a similar capacity, or utilizing this alternate connection as an emergency backup apparatus.

The above discussion has noted specific and preferred embodiments and applications of the invention, however, it is recognized that the physical size, either in terms of design cooling capacity or physical equipment parameters will be accommodated dependent upon the individual application. In the illustration of the supermarket cooling demands, these design considerations may include the store operating hours, relative size of the facility and other design factors. Each of the factors may be considered but are not a limitation to the present invention.

While only specific embodiments of the invention have been described and shown, it is apparent that various alterations and modifications can be made therein. It is, therefore, the intention to cover all such modifications and alterations as may fall within the scope of the appended claims.

Claims

1. A cooling system comprising at least one primary refrigeration cooled assembly (14;120) and a supplemental cooling system (12) connected thereto for reducing the temperature of a refrigerant in the primary refrigeration cooled assembly (14;120) upstream of a refrigerant cooled apparatus (34;132), wherein the primary refrigeration cooled assembly (14;120) comprises a refrigerant circuit with said refrigerant and wherein the supplemental cooling system (12) comprises:

   refrigerant means for providing a second refrigerant;

   thermal storage means (82) having a housing with a phase change material in said housing;

   freezing means for freezing at least a portion of the phase change material in the housing and for cooling a remaining portion of fluid phase change material to approximately the temperature of frozen phase change material, the freezing means being positioned in the housing and connected to the refrigerant means and wherein the freezing means is operable independently of the primary refrigeration cooled assembly (14;120);

   coupling means (16;136) coupled to the primary assembly refrigerant circuit for exchanging heat between refrigerant in the primary assembly refrigerant circuit and fluid phase change material in the supplemental cooling system, the coupling means (16;136) having a first fluid

path coupled to the primary assembly refrigerant circuit wherein in use refrigerant from the primary assembly refrigerant circuit flows through the first fluid path before returning to the primary assembly refrigerant circuit, and a second fluid path coupled to the thermal storage means (82) wherein in use fluid phase change material from the thermal storage means (82) flows through the second fluid path before returning to the thermal storage means (82); and

pumping means (40) for pumping the fluid phase change material from the thermal storage means (82) to the second fluid path and for returning the fluid phase change material to the thermal storage means (82);

wherein the fluid phase change material is at a cooler temperature in the second fluid path than the refrigerant in the first fluid path;

characterised in that said primary refrigeration cooled assembly further comprises:

compressing means (18) for compressing a refrigerant vapor from a first and low pressure to a second and higher pressure;

condensing means (26;124) separate from said coupling means and coupled to the compressing means (18) for condensing at least a portion of the refrigerant vapor at the second pressure to a liquid; and whereby

the refrigerant cooled apparatus (34;132) is coupled downstream from the condensing means (26;124), wherein refrigerant after passing through the refrigerant cooled apparatus (34;132) is recycled to the compressing means (18).

2. A cooling system as claimed in claim 1, wherein the primary refrigeration cooled assembly (14) comprises a low-temperature condensing application, whereby the coupling means (16) is an auxiliary condenser coupled between the primary assembly compressing means (18) and the primary assembly condensing means (26) in parallel with the primary assembly refrigerant circuit.

3. A cooling system as claimed in claim 1, wherein the primary refrigeration cooled assembly (120) comprises a sub-cooling application, whereby the coupling means (136) is a liquid refrigerant sub-cooler coupled between the primary assembly condensing means (124) and the refrigerant cooled apparatus (132) in series with the primary assembly refrigerant circuit.

4. A cooling system as claimed in claim 1, 2 or 3, wherein the primary assembly condensing means (26;124) is either an air cooled condenser or an evaporative condenser.

5. A cooling system as claimed in any preceding claim, further comprising a liquid receiver (100;130) coupled in parallel with the primary assembly refrigerant circuit between the primary assembly condensing means (26;124) and the primary assembly refrigerant cooled apparatus (34;132).

6. A cooling system as claimed in any preceding claim, wherein the supplemental cooling system refrigerant means comprises a refrigerant circuit having compressing means (18) for compressing the refrigerant and condensing means (76) for condensing the refrigerant.

7. A cooling system as claimed in claim 6, wherein the supplemental cooling system condensing means (76) is either an air-cooled condenser, a water-cooled or an evaporative condenser.

8. A cooling system as claimed in any preceding claim, wherein the primary assembly and/or supplemental cooling system compressing means (18) comprises a plurality of compressors (18) arranged in a parallel circuit to receive a vapor at a first and lower pressure for compression to a second and higher pressure.

9. A cooling system as claimed in claim 6, 7 or 8, further comprising diverting means (123, 125, 127) coupled between the supplemental cooling system condensing means (76) and the primary assembly compressing means (18), which diverting means (127) is actuable to connect the primary assembly compressing means (18) to the supplemental cooling system refrigerant circuit so that the primary assembly compressing means (18) operates as the supplemental cooling system compressing means (18).

10. A cooling system as claimed in any preceding claim, further comprising an air-cooling apparatus (160) having a coolant circuit with a thermal control valve (162) and a circulating pump (170) therein, the air-cooling apparatus (160) coupled to said circulating pump (170) to receive in a first mode, fluid phase change material from the supplemental cooling system by the diversion of said fluid phase change material to the circulating pump (170) and the air-cooling apparatus (160) and to return in a second mode the fluid phase change material direct to the thermal storage means (82).

11. A cooling system as claimed any of claims 1-9, further comprising a heat exchange device (174) having a coolant circuit, a circulating pump (170) con-

nected between the supplemental cooling system and the heat exchange device (174), a control valve (162) located downstream of the circulating pump (170) and being operable to route fluid phase change material to the circulating pump (170) for communication to said heat exchange device (174) and to couple fluid phase change material from the heat exchange device (174) to the supplemental cooling system and a signal and sensing device (182) coupled to said circulating pump (170) and operable to actuate said circulating pump (170) to communicate fluid phase change material to the heat exchange device (174).

12. A cooling system as claimed in claim 11, wherein said heat exchange device (174) is an air cooling apparatus.

Patentansprüche

1. Ein Kühlsystem umfassend mindestens eine primäre durch Kälteerzeugung gekühlte Anordnung (14; 120) und ein zusätzliches, damit verbundenes Kühlsystem (12), um die Temperatur eines Kältemittels in der primären durch Kälteerzeugung gekühlten Anordnung (14;120) in Strömungsrichtung vor einer Kältemittel-gekühlten Vorrichtung (34; 132) abzusenken, worin die primäre durch Kälteerzeugung gekühlte Anordnung (14;120) einen Kältemittelkreislauf mit dem Kältemittel aufweist und worin das zusätzliche Kühlsystem (12) umfaßt:

eine Kältemitteleinrichtung zur Bereitstellung eines zweiten Kältemittels;

eine thermische Speichereinrichtung (82), die ein Gehäuse aufweist, mit einem Phasenänderungsmaterial in diesem Gehäuse;

eine Gefriereinrichtung zum Gefrieren wenigstens eines Teils des Phasenänderungsmaterials in dem Gehäuse und zur Abkühlung eines verbleibenden Teils von flüssigem Phasenänderungsmaterial auf annähernd die Temperatur des gefrorenen Phasenänderungsmaterials, wobei die Gefiereinrichtung in dem Gehäuse angeordnet und mit der Kältemitteleinrichtung verbunden ist und worin die Gefriereinrichtung unabhängig von der primären durch Kälteerzeugung gekühlten Anordnung (14;120) betriebbar ist;

eine Kopplungseinrichtung (16;136), die mit dem Kühlmittelkreislauf der primären Anordnung verbunden ist, um Wärme zwischen Kältemittel in dem Kältemittelkreislauf der primären Anordnung und flüssigem Phasenänderungsmaterial in dem zusätzlichen Kühlsystem auszutauschen, wobei die Kopplungseinrichtung (16;136) einen ersten, mit dem Kältemittelkreislauf der primären Anordnung verbundenen Fluidweg aufweist, worin während des Gebrauchs Kältemittel von dem Kältemittelkreislauf der primären Anordnung durch den ersten Fluidweg strömt, bevor es in den Kältemittelkreislauf der primären Anordnung zurückfließt, sowie einen zweiten, mit der thermischen Speichereinrichtung (82) verbundenen Fluidweg, worin während des Gebrauchs flüssiges Phasenänderungsmaterial aus der thermischen Speichereinrichtung (82) durch den zweiten Fluidweg strömt, bevor es zu der thermischen Speichereinrichtung (82) zurückfließt; und

eine Pumpeinrichtung (40) zum Pumpen des flüssigen Phasenänderungsmaterials aus der thermischen Speichereinrichtung (82) zu dem zweiten Fluidweg und zur Rückführung des flüssigen Phasenänderungsmaterials zu der thermischen Speichereinrichtung (82);

worin sich das flüssige Phasenänderungsmaterial in dem zweiten Fluidweg auf einer niedrigeren Temperatur als das Kältemittel in dem ersten Fluidweg befindet;

dadurch gekennzeichnet, daß die primäre durch Kälteerzeugung gekühlte Anordnung darüberhinaus umfaßt:

eine Verdichtungseinrichtung (18) zum Verdichten eines Kältemitteldampfes von einem ersten und niedrigen Druck auf einen zweiten und höheren Druck;

eine Kondensationseinrichtung (26;124), die von der Kopplungseinrichtung getrennt und mit der Verdichtungseinrichtung (18) verbunden ist, um wenigstens einen Teil des Kältemitteldampfes bei dem zweiten Druck zu einer Flüssigkeit zu kondensieren; und wobei

die Kältemittel-gekühlte Vorrichtung (34;132) in Strömungsrichtung nach der Kondensationseinrichtung (26;124) angeschlossen ist, wodurch das Kältemittel nach dem Durchlaufen der Kältemittel-gekühlten Vorrichtung (34;132) auf die Verdichtungseinrichtung (18) zurückgeführt wird.

2. Ein Kühlsystem nach Anspruch 1, worin die primäre durch Kälteerzeugung gekühlte Anordnung (14) eine Niedertemperatur-Kondensationsanordnung umfaßt, wobei die Kopplungseinrichtung (16) ein Hilfskondensator ist, der zwischen der Verdich-

tungseinrichtung (18) der primären Anordnung und der Kondensationseinrichtung (26) der primären Anordnung angeschlossen ist, und zwar parallel zu dem Kältemittelkreislauf der primären Anordnung.

3. Ein Kühlsystem nach Anspruch 1, worin die primäre, durch Kälteerzeugung gekühlte Anordnung (120) eine Nebenkühlanordnung umfaßt, wobei die Kopplungseinrichtung (136) ein Nebenkühler für flüssiges Kältemittel ist, der zwischen der Kondensationseinrichtung (124) der primären Anordnung und der Kältemittel-gekühlte Vorrichtung (132) angeschlossen ist, und zwar in Reihe mit dem Kältemittelkreislauf der primären Anordnung.

4. Ein Kühlsystem nach den Ansprüchen 1, 2 oder 3, worin die Kondensationseinrichtung (26;124) der primären Anordnung entweder ein luftgekühlter Kondensator oder ein Kondensator des Verdampfertyps ist.

5. Ein Kühlsystem nach einem der vorangegangenen Ansprüche, darüberhinaus umfassend einen Flüssigkeitsbehälter (100;130), der parallel zu dem Kältemittelkreislauf der primären Anordnung zwischen der Kondensationseinrichtung der primären Anordnung (26;124) und der Kältemittel-gekühlten Vorrichtung (34;132) der primären Anordnung angeschlossen ist.

6. Ein Kühlsystem nach einem der vorangegangenen Ansprüche, worin die Kältemitteleinrichtung des zusätzlichen Kühlsystems einen Kältemittelkreislauf umfaßt, der eine Verdichtungseinrichtung (18) zum Verdichten des Kältemittels und eine Kondensationseinrichtung (76) zum Kondensieren des Kältemittels aufweist.

7. Ein Kühlsystem nach Anspruch 6, worin die Kondensationseinrichtung (76) des zusätzlichen Kühlsystems entweder ein luftgekühlter Kondensator, ein wassergekühlter Kondensator oder ein Kondensator des Verdampfertyps ist.

8. Ein Kühlsystem nach einem der vorangegangenen Ansprüche, worin die Verdichtungseinrichtung (18) der primären Anordnung und/oder des zusätzlichen Kühlsystems eine Mehrzahl von Verdichtern (18) umfaßt, die in Parallelschaltung angeordnet sind, um einen Dampf bei einem ersten und niedrigeren Druck zur Verdichtung auf einen zweiten und höheren Druck aufzunehmen.

9. Ein Kühlsystem nach Anspruch 6, 7 oder 8, darüberhinaus umfassend Ableitungseinrichtungen (123,125,127), die zwischen der Kondensationseinrichtung (76) des zusätzlichen Kühlsystems und der Verdichtungseinrichtung (18) der primären Anordnung angeschlossen ist, welche Ableitungseinrichtung (127) verwendet werden kann, um die Verdichtungseinrichtung (18) der primären Anordnung mit dem Kältemittelkreislauf des zusätzlichen Kühlsystems zu verbinden, so daß die Verdichtungseinrichtung (18) der primären Anordnung als Verdichtungseinrichtung (18) des zusätzlichen Kühlsystems arbeitet.

10. Ein Kühlsystem nach einem der vorangegangenen Ansprüche, darüberhinaus umfassend eine Luftkühlungsvorrichtung (160), die einen Kühlmittelkreislauf mit einem Wärmesteuerungsventil (162) und einer Umwälzpumpe (170) darin aufweist, wobei die Luftkühlungsvorrichtung (160) mit der Umwälzpumpe (170) verbunden ist, um in einem ersten Betriebszustand flüssiges Phasenänderungsmaterial aus dem zusätzlichen Kühlsystem durch Ableitung des Phasenänderungsmaterials auf die Umwälzpumpe (170) und die Luftkühlungsvorrichtung (160) aufzunehmen und in einem zweiten Betriebszustand das flüssige Phasenänderungsmaterial direkt an die thermischen Speichereinrichtungen (82) zurückzuleiten.

11. Ein Kühlsystem nach einem der Ansprüche 1 bis 9, darüberhinaus umfassend eine Wärmetauschereinrichtung (174), die einen Kühlmittelkreislauf aufweist, eine Umwälzpumpe (170), die zwischen dem zusätzlichen Kühlsystem und der Wärmetauschereinrichtung (174) angeschlossen ist, ein Steuerventil (162), das in Strömungsrichtung nach der Umwälzpumpe angeordnet ist und das betrieben werden kann, um auf die Umwälzpumpe (170) flüssiges Phasenänderungsmaterial zur Übertragung auf die Wärmetauschereinrichtung (174) und flüssiges Phasenänderungsmaterial aus der Wärmetauschereinrichtung (174) in das zusätzliche Kühlsystem zu leiten, und eine Signal- und Fühlereinrichtung (182), die mit der Umwälzpumpe (170) verbunden ist und betrieben werden kann, um die Umwälzpumpe (170) derart zu betätigen, daß flüssiges Phasenänderungsmaterial auf die Wärmetauschereinrichtung (174) gefördert wird.

12. Ein Kühlsystem nach Anspruch 11, worin die Wärmetauschereinrichtung (174) eine Luftkühlungsvorrichtung ist.

Revendications

1. Système de refroidissement comprenant au moins un ensemble refroidi de réfrigération primaire (14; 120) et un système de refroidissement complémentaire (12) raccordé à cet ensemble pour réduire la température d'un réfrigérant situé dans l'ensemble refroidi de réfrigération primaire (14;120) en amont

d'un appareil (34;132) refroidi par le réfrigérant, et dans lequel l'ensemble refroidi de réfrigération primaire (14;120) comprend un circuit à réfrigérant contenant ledit réfrigérant et dans lequel le système de refroidissement complémentaire (12) comprend :

des moyens de délivrance d'un réfrigérant servant à délivrer un second réfrigérant;
des moyens de stockage thermique (82) comportant une enceinte avec une substance à changement de phase logée dans ladite enceinte;
des moyens de congélation pour congeler au moins une partie de la substance de changement de phase située dans l'enceinte et refroidir une partie restante d'une substance fluide à changement de phase en l'amenant approximativement à la température de la substance à changement de phase gelée, les moyens de congélation étant disposés dans l'enceinte et raccordés aux moyens de délivrance du réfrigérant et dans lequel les moyens de congélation peuvent être actionnés indépendamment de l'ensemble refroidi de réfrigération primaire (14;120);
des moyens d'accouplement (16;136) couplés au circuit à réfrigérant de l'ensemble primaire pour réaliser un échange de chaleur entre le réfrigérant situé dans le circuit réfrigérant de l'ensemble primaire et la substance fluide à changement de phase située dans le système de refroidissement complémentaire, les moyens de couplage (16;136) possédant un premier trajet du fluide couplé au circuit à réfrigérant de l'ensemble primaire, dans lequel en fonctionnement le réfrigérant provenant du circuit à réfrigérant de l'ensemble primaire circule dans le premier trajet de fluide avant de revenir au circuit réfrigérant de l'ensemble primaire, et un second trajet de fluide couplé aux moyens de stockage thermique (82), auquel cas en fonctionnement la substance fluide à changement de phase provenant des moyens de stockage thermique (82) circule dans le second trajet de fluide avant de revenir aux moyens de stockage thermique (82); et
des moyens de pompage (40) pour pomper la substance fluide à changement de phase depuis les moyens de stockage thermique (82) au second trajet pour le fluide et pour renvoyer la substance fluide à changement de phase aux moyens de stockage thermique (82);
la substance fluide à changement de phase, situé dans le second trajet de fluide, étant à une température inférieure à celle du réfrigérant situé dans le premier trajet du fluide;

caractérisé en ce que ledit ensemble refroidi de réfrigération primaire comprend en outre :

des moyens de compression (18) pour comprimer une vapeur du réfrigérant depuis une première basse pression à une seconde pression plus élevée;
des moyens de condensation (26;124) séparés desdits moyens de couplage et couplés aux moyens compresseurs (18) pour condenser au moins une partie de la vapeur du réfrigérant à la seconde pression pour l'amener à l'état liquide; et
dans lequel un appareil (34;132) refroidi par le réfrigérant est couplé en aval des moyens de condensation (26;134), le réfrigérant étant renvoyé par recyclage aux moyens de compression (18) après avoir traversé l'appareil (34; 132) refroidi par le réfrigérant.

2. Système de refroidissement selon la revendication 1, dans lequel l'ensemble refroidi de réfrigération primaire (14) comprend une unité de condensation à basse température, les moyens de couplage (16) étant un condenseur auxiliaire branché entre les moyens de compression (18) de l'ensemble primaire et les moyens de condensation (26) de l'ensemble primaire, en parallèle avec le circuit à réfrigérant de l'ensemble primaire.

3. Système de refroidissement selon la revendication 1, dans lequel un ensemble refroidi de réfrigération primaire (120) comprend une unité de sous-refroidissement, les moyens de couplage (136) étant un dispositif de sous-refroidissement du réfrigérant liquide branché entre les moyens de condensation (124) de l'ensemble primaire et l'appareil (132) refroidi par le réfrigérant, en série avec le circuit à réfrigérant de l'ensemble primaire.

4. Système de refroidissement selon la revendication 1, 2 ou 3, dans lequel les moyens de condensation (26;124) de l'ensemble primaire sont un condenseur refroidi par air ou un condenseur à évaporation.

5. Système de refroidissement selon l'une quelconque des revendications précédentes, comprenant en outre un récepteur de liquide (100;130) branché en parallèle avec le circuit à réfrigérant de l'ensemble primaire, entre les moyens de condensation (26; 124) de l'ensemble primaire et l'appareil (34;132) refroidi par le réfrigérant, de l'ensemble primaire.

6. Système de refroidissement selon l'une quelconque des revendications précédentes, dans lequel les moyens de délivrance du réfrigérant du système de refroidissement complémentaire comprennent

un circuit à réfrigérant comprenant des moyens de compression (18) pour comprimer le réfrigérant et des moyens de condensation (76) pour condenser le réfrigérant.

7. Système de refroidissement selon la revendication 6, dans lequel les moyens de condensation (76) du système de refroidissement complémentaire sont un condenseur refroidi par air, un condenseur refroidi par eau ou un condenseur à évaporation.

8. Système de refroidissement selon l'une quelconque des revendications précédentes, dans lequel les moyens de compression (18) de l'ensemble primaire et/ou du système de refroidissement complémentaire comprennent une pluralité de compresseurs (18) branchés selon un montage en parallèle pour recevoir de la vapeur à une première pression inférieure pour la comprimer à une seconde pression supérieure.

9. Système de refroidissement selon la revendication 6, 7 ou 8, comprenant en outre des moyens de dérivation (123,125,127) branchés entre les moyens de condensation (76) du système de refroidissement complémentaire et les moyens de compression (18) de l'ensemble primaire, lesquels moyens de dérivation (127) peuvent être actionnés pour raccorder les moyens de compression (18) de l'ensemble primaire au circuit à réfrigérant du système de refroidissement complémentaire de sorte que les moyens de compression (18) de l'ensemble primaire fonctionnent en tant que moyens de compression (18) du système de refroidissement complémentaire.

10. Système de refroidissement selon l'une quelconque des revendications précédentes, comprenant en outre un appareil de refroidissement par air (160) possédant un circuit de refroidissement contenant une vanne de commande thermique (162) et une pompe de circulation (170), l'appareil de refroidissement par air (160) couplé à ladite pompe de circulation (170) pour recevoir, dans un premier mode, une substance fluide à changement de phase provenant du système de refroidissement complémentaire, au moyen de la dérivation de ladite substance fluide à changement de phase en direction de la pompe de circulation (170), et de l'appareil de refroidissement par air (160) et pour renvoyer, dans un second mode, la substance fluide à changement de phase, directement aux moyens de stockage thermique (82).

11. Système de refroidissement selon l'une quelconque des revendications 1-9, comprenant en outre un dispositif d'échange de chaleur (174) comportant un circuit à réfrigérant, une pompe de circulation (170) branchée entre le système de refroidissement complémentaire et le dispositif d'échange de chaleur (174), une vanne de commande (162) située en aval de la pompe de circulation (170) et pouvant agir de manière à envoyer une substance fluide à changement de phase à la pompe de circulation (170) pour communiquer avec ledit dispositif d'échange de chaleur (174) et transférer la substance fluide à changement de phase depuis le dispositif d'échange de chaleur (174) au système de refroidissement complémentaire et un dispositif de transmission de signal et de détection (182) couplé à ladite pompe de circulation (170) et pouvant agir de manière à actionner ladite pompe de circulation (170) pour transférer la substance fluide de changement de phase au dispositif d'échange de chaleur (174).

12. Système de refroidissement selon la revendication 11, dans lequel ledit dispositif d'échange de chaleur (174) est un appareil de refroidissement par air.

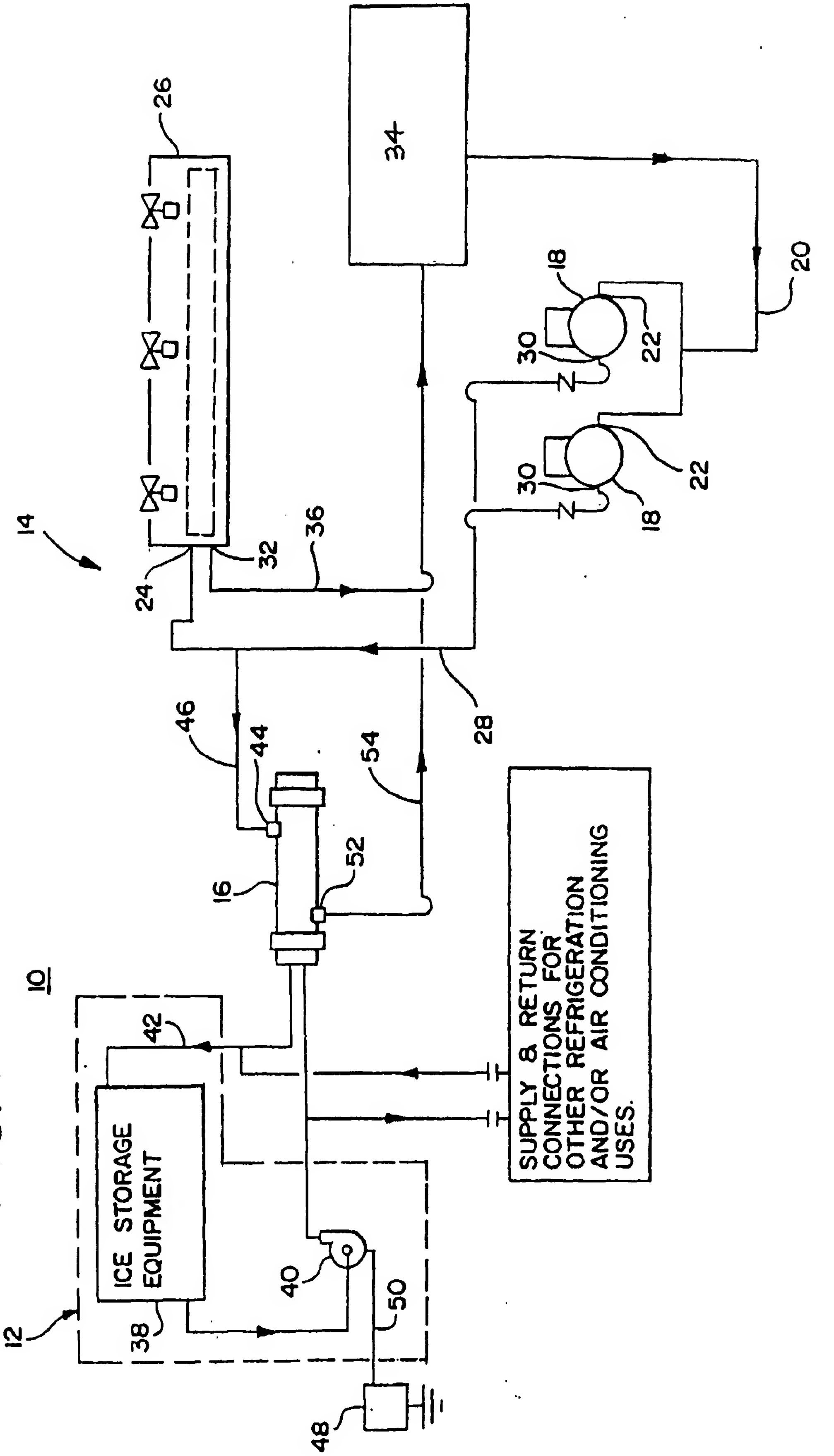
26
34
20
18
30
22
22
30
18
14
36
32
24
28
46
44
54
52
16
10
42
SUPPLY & RETURN CONNECTIONS FOR OTHER REFRIGERATION AND/OR AIR CONDITIONING USES.
ICE STORAGE EQUIPMENT
40
50
12
38
48

FIG. 1

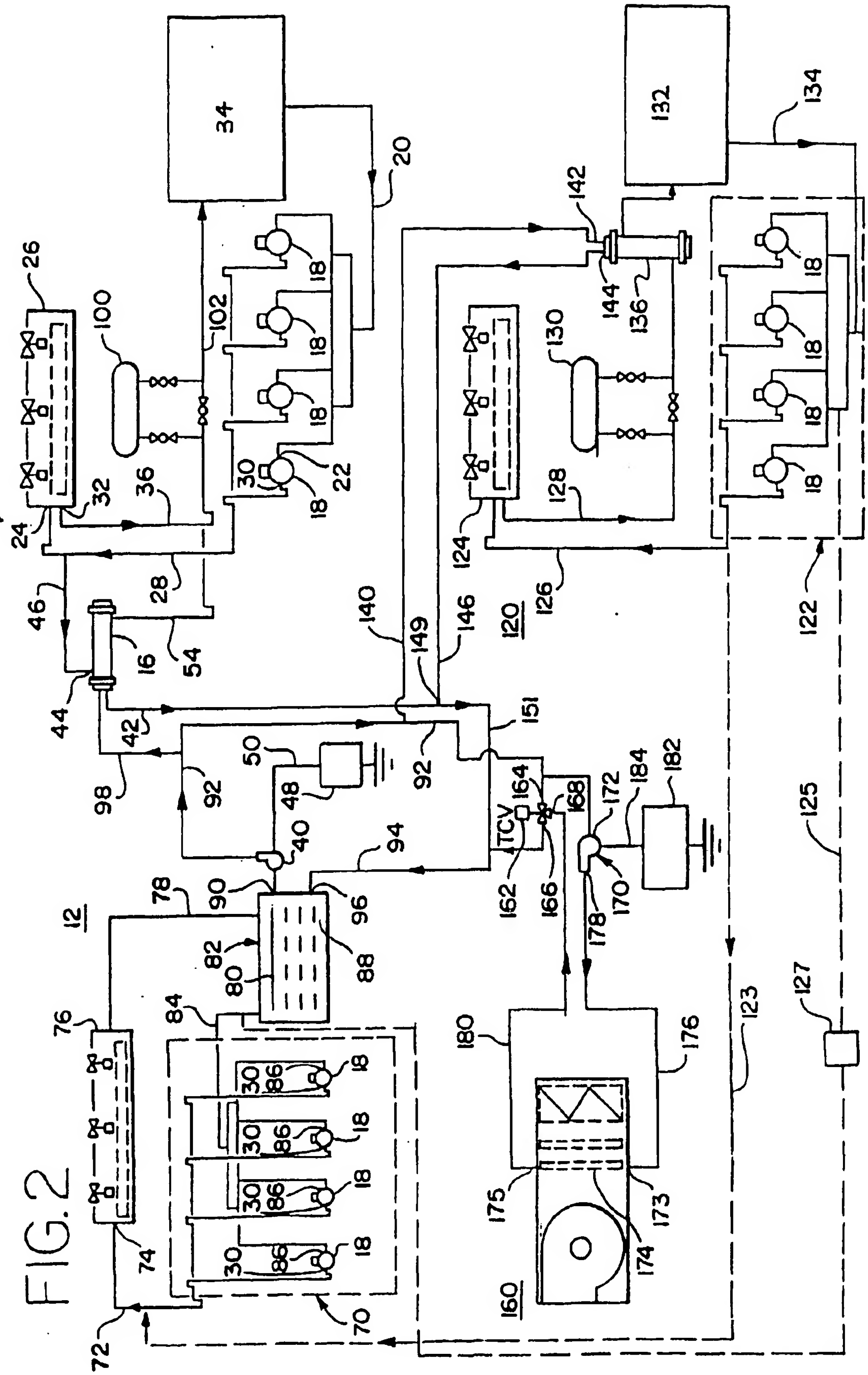

FIG. 2